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LIGHTING DATA

EDISON LAMP WORKS

OF GENERAL ELECTRIC COMPANY

GENERAL SALES OFFICE HARRISON, N. J.

The Lighting of Metal Working Plants

Information compiled by

A. L. POWELL

Lighting Service Department

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The Lighting of Metal Working Plants

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Introductory

Economy in production is most essential at all times if business is to prosper. Just now the question is of supreme importance in view of the necessity for lowering costs in every department. A mere curtailment of certain expenses does not necessarily mean a reduction in cost. As an extreme case one might eliminate heat in the winter and save in coal consumption. The result is self-evident. The numbed fingers could not function quickly and the workers would lose a great amount of time in trying to keep warm.

Lighting might be cut down and the power bill reduced, but we would have a parallel case. Under the low intensity every movement would be slowed down and the cost per unit of output would mount at a surprising rate. Bulletin Index 17, "Light and Production," points out the fact that high level illumination without doubt makes it possible for each operator to turn out more work per day and is therefore an especially essential element to efficient shop management. No matter how efficient the machinery or how well trained the workers may be, if the efforts of the two cannot be coordinated then production will be slowed down. High level lighting makes this coordination possible.

In times of economy *unnecessary expenses must be eliminated.* Every manufacturing plant has some of these in the form of compensation to injured workmen. Careful investigators have shown that a high percentage of industrial accidents are avoidable and further, that improper lighting is responsible for many of these. A suitable intensity of well diffused non-glaring light eliminates many accidents as pointed out in Bulletin Index 18, "Light and Safety," and hence reduces costs.

Modern lighting, in addition, reduces spoilage, improves sanitation, provides better working conditions and in cases where obsolete types of lamps are replaced, may not only furnish high level lighting, but actually reduce the cost and conserve the coal pile. The subject is so important that those responsible for producing commodities at the lowest cost cannot afford to neglect a careful consideration of the lighting layout in the shop.

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Methods of Lighting

Localized lighting was the first method used for shop lighting. It still has advantages for certain operations, but has been generally superseded by general illumination with more efficient, larger lamps. One of the reasons for this replacement has been the movement toward the prevention of glare. Local lights very frequently pro-

Fig. 1
Night View of a Typical Machine Shop Well Lighted by 200-watt MAZDA C Lamps in Dome Enameled Steel Reflectors with Glass Diffusing Globes on Centers 10 x 12 Feet, Eleven Feet Above the Floor. This localized general arrangement provides eleven foot-candles of such a quality that reflections from polished surfaces are materially reduced. The arrangement of units over the benches is worthy of note

duce glaring conditions. An operator will not take the time or trouble to place the lamp with its reflector so that the direct light or the reflected light from highly polished working surfaces does not strike his eyes. Breakage of lamps is liable to be quite high, as well as the cost of wiring. With local lighting the very bright spots directly beneath the lamps are in severe contrast to the rest of the room. Nevertheless, where extremely fine work or internal boring is being carried on, the high intensity or direction of light

necessary may compel the installation of drop lamps. They should always be supplemented with general illumination.

General illumination is now in extensive use for all types of industrial lighting. With a well designed general lighting system work can be carried on effectively. Relatively few outlets are required, and efficient MAZDA C lamps can be used.

Fig. 2
A General Lighting Arrangement is a Well Lighted Shop. Outlets are spaced 15 x 14 feet. 300-watt MAZDA C lamps in reflecto-cap diffusers are hung eleven feet high. Work can be carried out effectively in a shop illuminated in this manner

When the arrangement of a shop is such that the greater part of the area needs only a relatively low intensity of general illumination, but some few operations require a much higher intensity, the most economical plan is to supplement overhead lighting with local lamps judiciously placed. This is especially true of machine shops with automatic machinery. The local lamp is necessary when setting the tool, while the general illumination is sufficient for all other operations. In some of the most modern plants where portable units are used only occasionally, they are handled in the same way as special tools. They are kept in the tool room and

checked out in the same manner as a special chuck or cutting tool. Conveniently located baseboard or wall outlets are installed for attaching them.

The most generally applicable system of machine shop lighting has been termed "localized general." Usually a high intensity is required along the row of machines or benches, while a lower illumination is sufficient for the remainder of the room. This effect of varied intensity is accomplished by placing medium sized lamps relative to the machines at a height of nine or ten feet. The maximum intensity is then delivered on the work from the correct direction and the spread light takes care of the surrounding areas, aisles, etc. The localized general system has practically all the advantages of the drop light in getting the light where it is most needed, and yet the lighting units are out of reach, not likely to be tampered with, and the whole room is well illuminated.

General Considerations

The bowl enameled MAZDA C lamp is most universally applicable for general or localized general illumination. It is efficient and sturdy. The smooth white mineral coating on the lower portion of the bulb diffuses the light, eliminates glare from the bright filament and makes the shadows soft and feathery rather than dense and harsh.

For use in drop lamps or portables, the MAZDA mill type lamps are desirable. These are of the vacuum type with a coiled filament in a relatively small tipless bulb. The special features of construction such as the short stem and flexible supports give them greater strength than the regular low wattage MAZDA B lamps. The mill type MAZDA lamp is therefore especially serviceable under conditions of vibration or repeated mechanical shocks.

Where a demand is experienced in the metal working industry, such as selecting brass and other alloys by color, a modification of light toward daylight color value is sometimes desirable. The MAZDA daylight lamp therefore proves of value here.

For more detailed information on this general subject, see Bulletin Index 1, "Edison MAZDA Lamps, Theory and Characteristics."

It has been said that light may be produced by lamps without reflectors, but not by reflectors without lamps. This statement is very true, but lamps without reflectors not only waste power but also are a cause of ineffective lighting due to glare. Thus the

purposes of reflectors are two-fold: to distribute the light most efficiently on the working plane, and to protect the eyes of the workmen.

Glare in the workmen's eyes due to unshielded lamps should be carefully avoided, for it produces a serious effect upon the eye which not only reduces its acuity but also produces a tiring effect upon the entire body. The best means of avoiding such an effect is to use proper reflector equipment.

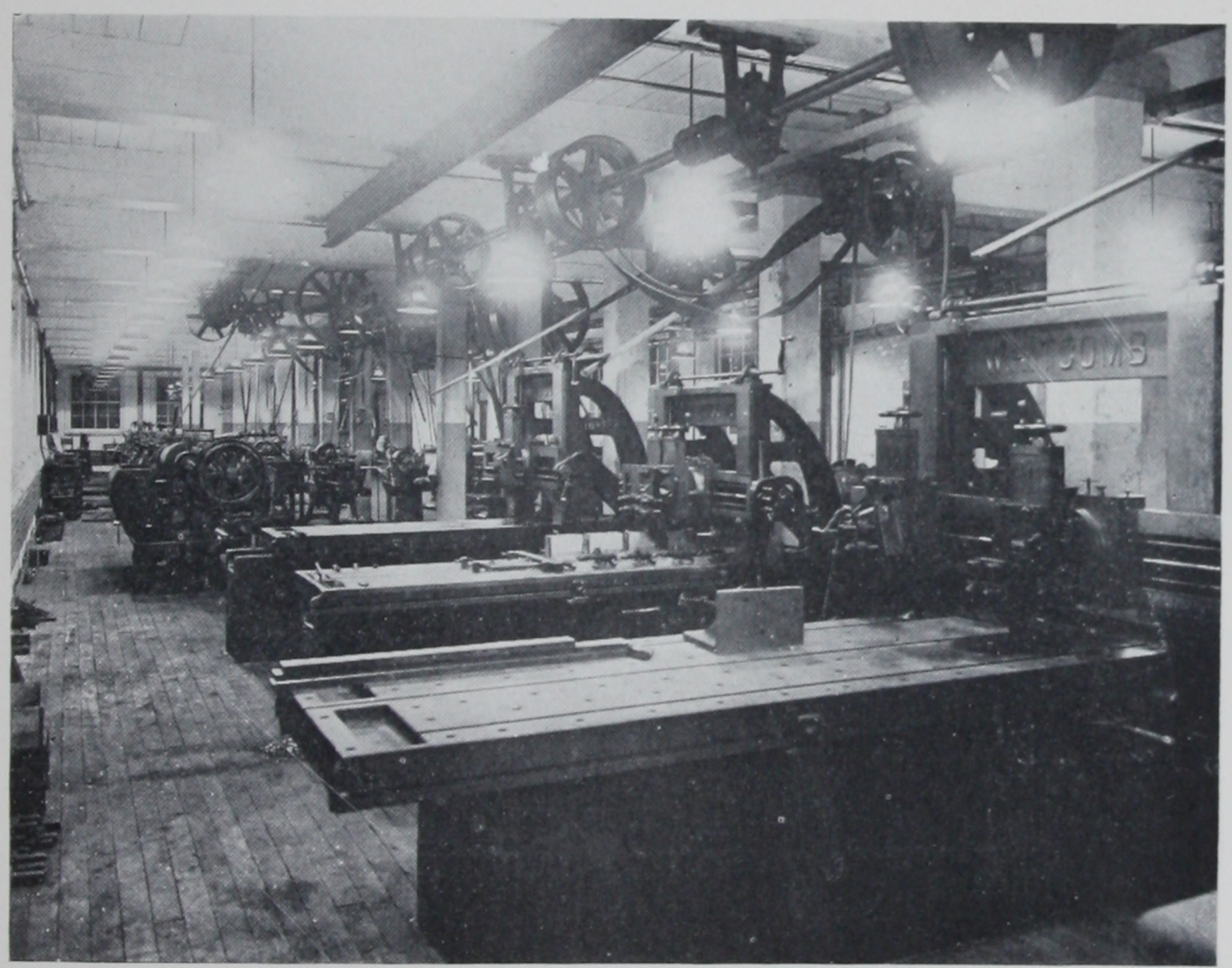

Fig. 3
A Group of Planers Lighted by 150-watt MAZDA C Lamps in Glass Top Dome Reflectors on 8-foot Centers Ten Feet High. The intensity is over twelve foot-candles. The room assumes a cheerful appearance due to the illuminated ceiling

Practically all the types of reflectors discussed in Bulletin Index 22 have been applied for the lighting of metal working plants as shown in the various accompanying illustrations.

The RLM Standard Dome reflector is the most widely used type for general or localized general illumination. It gives a desirable distribution of light with adequate illumination on vertical surfaces, is efficient, easy to clean, and so designed that direct glare is reduced to a satisfactory minimum. (Figs. 11 and 12.)

The glass top dome has similar properties but the small section of opal glass inserted near the holder transmits a portion of the light upward. This produces more cheerful surroundings and promotes safety in the operation of belting and shafting. (Figs. 3 and 8.)

The deep bowl metal reflector gives a lower cut off, in other words, the lamp is not visible at the same angle. This very fact, however, tends to reduce the amount of light on vertical surfaces and although there may be excellent illumination on the working

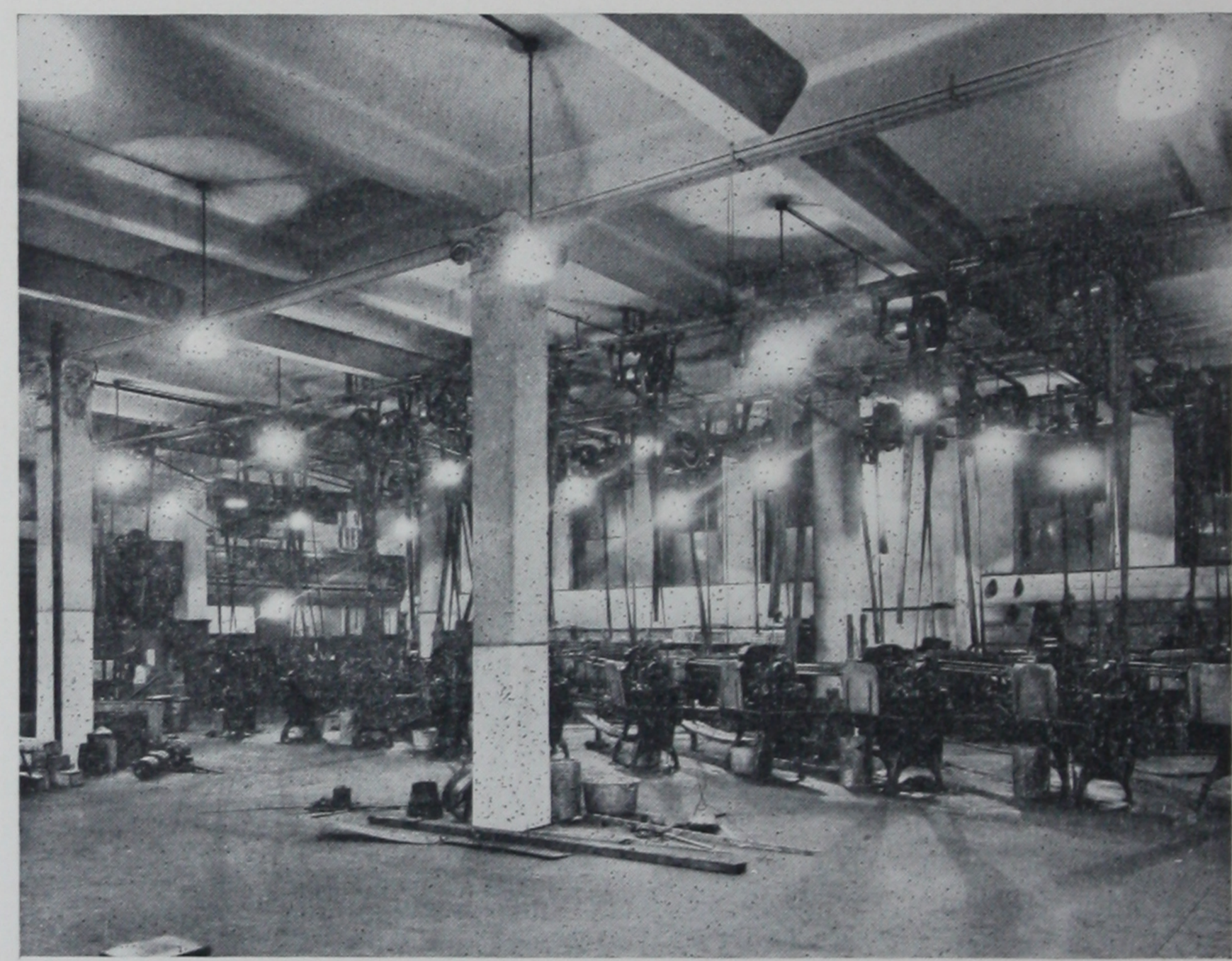

Fig. 4
A Group of Automatic Lathes Lighted by 150-watt Mazda C Lamps in Deep Bowl Prismatic Glass Reflectors on 10½-foot Centers Thirteen Feet High. The eight foot-candles provided are indeed adequate for this work

plane, a room often appears dull and cheerless when bowl reflectors are employed. Light colored surroundings reflecting and diffusing the light tend to overcome this difficulty. The deep bowl reflector is especially serviceable in local lighting with low hung lamps. (Fig. 6.)

Angle metal reflectors are used where especially high illumination is required on vertical surfaces and where lighting units must be located on the side walls. They are frequently placed below

the crane track and should generally be supplemented by overhead units. (Fig. 10.)

There are a number of types of specially designed metal reflector equipments for industrial lighting which provide additional means of diffusing the light. Sometimes a polished metal cap is placed over the lower half of the lamp bulb to cut off the direct light from the lamp. In other instances, diffusion is accomplished by opal glass diffusing caps and some devices employ a shield of

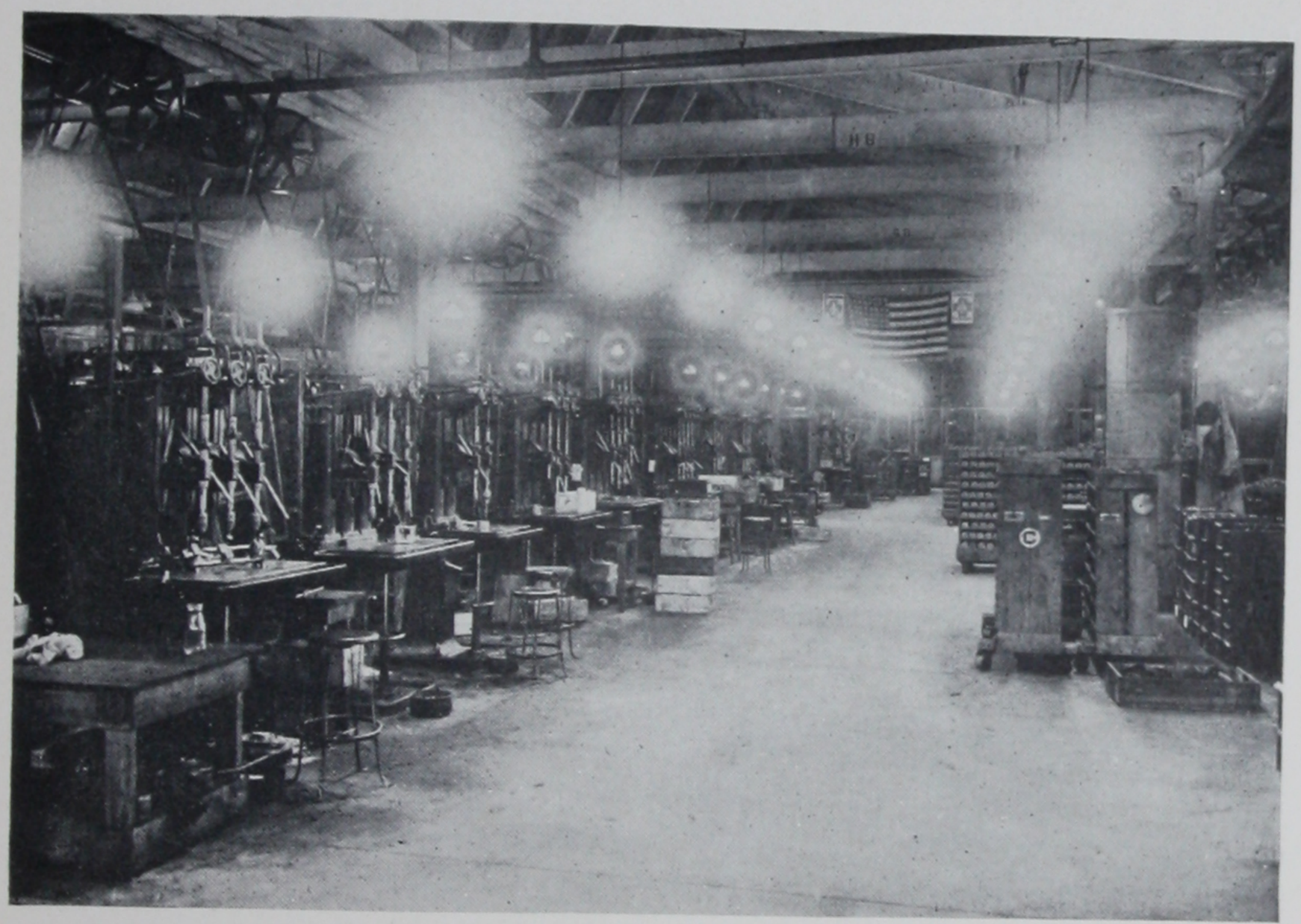

Fig. 5
100-watt MAZDA Lamps in Bowl Shaped Opalescent Glass Reflectors Nine Feet High, Spaced 8 x 10 Feet are Used to Light This Row of Drill Presses. Work under such conditions is pleasant

metal on a level with the filament. If the reflector itself is properly designed, these additional accessories tend to eliminate sharp shadows and annoying reflections from the work at a reduction in total output of light and a somewhat higher cost of equipment. (Figs. 1 and 2.)

Prismatic, mirrored and dense opal deep bowl glass reflectors are also used. These can be very efficient and give suitable distributions of light. The translucent types produce a bright, cheerful room. While it is evident that the likelihood of breakage is much greater than where metal reflectors are employed the hazard is not as great as often assumed. (Figs. 4 and 5.)

Enclosing or semi-enclosing units of opalescent or diffusing glass find quite an extensive application. They produce excellent diffusion with slight sacrifice in efficiency. A room so lighted is generally agreeable and attractive.

Conditions in the metal working plant are generally such as to make the installation of indirect systems of lighting inexpedient, but if unusually clean surroundings prevail, the qualities of indirect lighting warrant consideration.

Fig. 6

General Illumination of a Power Press Room. 100-watt bowl frosted MAZDA lamps in deep bowl steel reflectors are hung nine and one half feet high on 10-foot centers. The illumination at the machine is four foot-candles. The white side walls eliminate any impression of dinginess and reflect light under overhanging parts of the presses

Whatever system of illumination is chosen, it is good business to provide light colored walls and ceilings and refinish these at frequent intervals. Light which would otherwise be wasted is conserved as shown in Bulletin Index 15, "Effect of Color of Walls and Ceilings on Resultant Illumination." The importance of a well supervised, carefully planned system of cleaning lamps and reflectors cannot be overemphasized. Many a complaint of poor lighting conditions is due to a marked diminution in intensity resulting from an accumulation of dirt and dust. The effects of this are far greater than one would imagine and the shop superin-

tendent is urged to study Bulletin Index 14, "The Maintenance of the Lighting System."

In many plants lighting circuits are not separate from the power circuits and 220-volt systems in vogue. It is possible to secure lamps for operation on 220-volt circuits but from physical considerations these cannot be as efficient, sturdy or of a general quality comparable with those for use on 110-volt circuits. It is

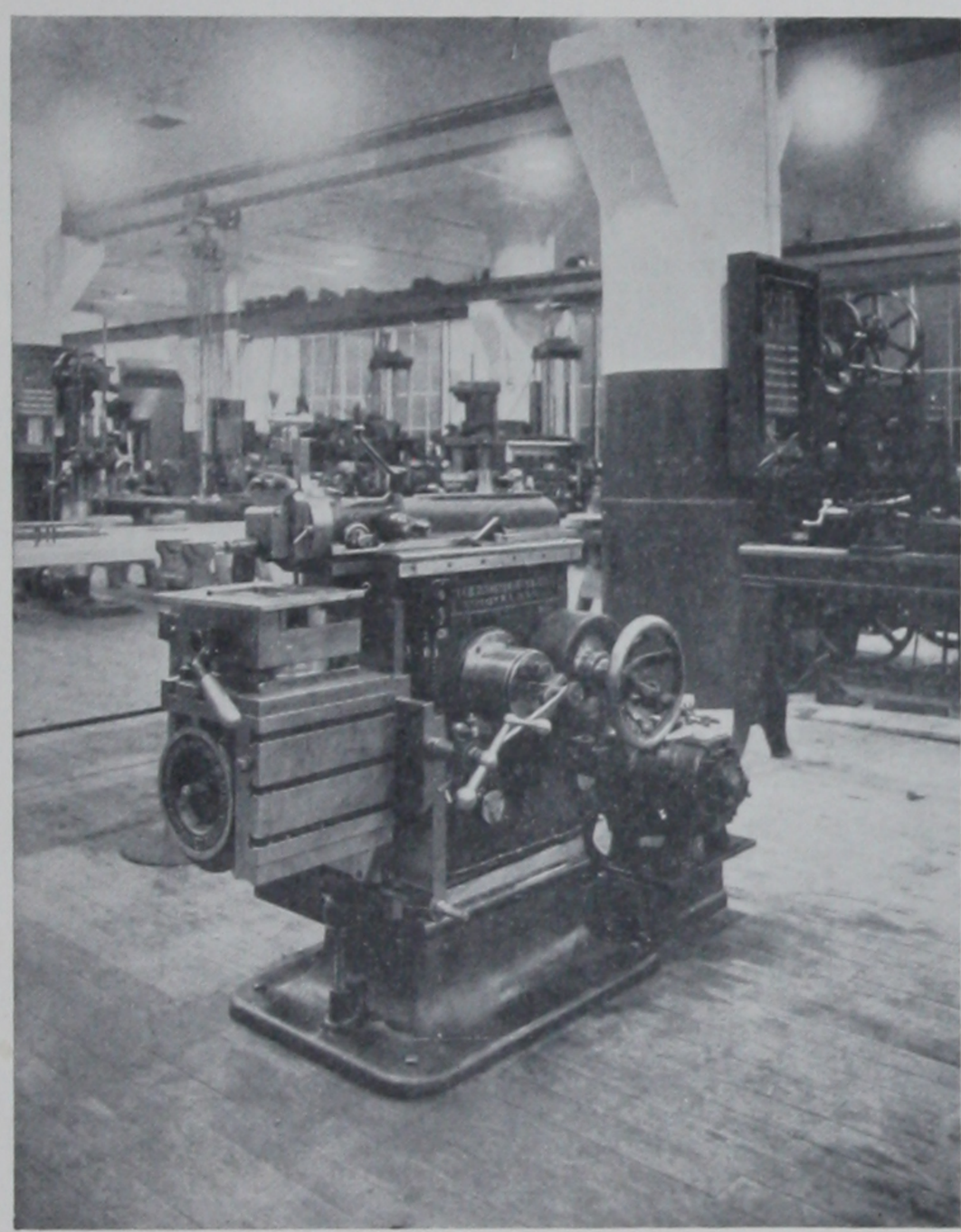

Fig. 7
Close Up Night View of a Shaper Installed in a Large Machine Shop. There are four outlets in each 25-foot bay. 100-watt clear MAZDA C lamps in dome type reflectors are placed close to the 17-foot ceiling. It is apparent that no drop lamps are required. The excellent illumination on vertical surfaces should be noted

most desirable therefore to provide 110 volts for lighting and distinct savings are possible through making the necessary changes as indicated in Bulletin Index 4, "110- Versus 220-Volt Circuits from the Standpoint of Lighting Service."

Detailed Recommendations

There are two characteristic types of buildings devoted to metal working which require different methods of lighting.

A. Those having relatively high ceilings, 20 to 60 feet, with a crane traveling the length of the bay (center bay). Figs. 10, 11 and 12 show typical structures.

B. Those with low ceilings, 10 to 15 feet, machines frequently driven by overhead shafting (side bays). Figs. 1 to 8 illustrate different forms of construction.

In the first case units must be hung high, above the crane travel, or placed on the supporting columns below the crane track. In the second case, shafting and belts are likely to cast shadows.

Larger, rougher work is usually carried on in the high ceiling room and finer work in the side bays.

Overhanging parts of many metal working machines tend to cast shadows on vital areas unless the proper direction of predominant light is secured. This question is of particular importance in the room where units must be hung low, for any individual machine generally receives most of its light from only one unit. In the other case with lamps well above the floor each machine receives light from a number of units, thus reducing the tendency for dense shadows to be produced.

We may divide the operations in the metal working industry into four general headings: a—bench work, b—machine tool work, c—sheet metal work, d—assembling, painting, etc.

Bench Work

Many processes are carried on at the benches, such as assembling small parts, soldering, sorting, filing, and general vise work. It is apparent that different intensities of illumination will be required.

Benches fall in two general groups, single benches two or three feet wide along the walls and single or double benches away from the walls.

Single benches along the walls should be lighted by a row of lamps about six inches in from the forward edge of the bench spaced on 6- to 10-foot centers with from 40- to 100-watt bowl frosted or bowl enameled MAZDA lamps in deep bowl or RLM standard dome reflectors. The size of lamp will depend on the fineness of the work and the spacing on the location of the vises or working points. It is desirable to locate units between vises rather than directly above them for with this arrangement light is received from the two sides and the operator is less likely to cast a shadow on the work. The units for bench lighting should be hung about five feet above the bench.

Where general illumination is used for the shop with outlets symmetrically spaced as for example, four outlets on ten-foot centers per twenty-foot bay, it is often feasible to move the first row of outlets two or three feet nearer the wall than would be employed for a strictly symmetrical arrangement and thus obtain

satisfactory bench lighting with but little sacrifice of general illumination and a minimum number of outlets. Such a scheme is followed in the plant illustrated in Fig. 8 where outlets are on eight-foot centers.

For benches away from the wall, general illumination is quite satisfactory, provided fairly close spacing of outlets (not over ten- or twelve-foot centers for ordinary conditions) is adhered to.

Fig. 8
Night View of Well Lighted Benches and Assembly Area. 150-watt MAZDA C lamps in glass top dome reflectors are spaced on 8-foot centers. Units for general illumination are close to the 12-foot ceiling while those over the benches are eight feet high. Outlets are located between vises. The even distribution and the ease with which every detail is clearly discernible is apparent

Where the ceiling is very low or the work exacting, localized general illumination with the units arranged as suggested for benches along the wall is sometimes necessary. Again where minute parts are handled, such as in the watch factory, or for very close inspection work, local lighting offers the most economical means of providing the high intensity (fifty foot-candles and upwards) which is necessary; this should, of course, be supplemented by general illumination.

The intensity for bench lighting depends on the type of work carried on and ranges from about six foot-candles for soldering to twenty foot-candles for accurate fitting of machine parts.

It is almost always desirable to avoid specular or image reflections of the light sources from polished surfaces, yet there are a few exceptional cases where such reflections are necessary if the work is to be carried on satisfactorily by artificial light. One can not illuminate a piece of polished metal so that imperfections will show up by diffuse reflection, as they would in some cloth, for example.

Fig. 9
The Moving Parts and Cutting Edges in the Sheet Metal Shop Should be Easily Visible as in This Case Where a Uniform Distribution of Outlets on 15-foot Centers is Provided. 150-watt bowl frosted MAZDA lamps in dome type reflectors produce an average intensity of five foot-candles

When inspecting glossy surfaces with natural light, the inspector holds the object so that the sky is reflected from its surface and thus detects irregularities. With artificial light it is necessary to duplicate this condition by having a relatively large diffusing source so placed that the inspector can view the reflection of this in the surface of the metal.

Machine Tool Work

There are a few processes, including deep boring, punching and pressing of large blanks, lathe work on minute parts, such as watch mechanisms and the like, which require local lamps. With these few exceptions, machine tool work can be carried on most effectively with the artificial lighting taking the form of overhead units. This statement is borne out by numerous satisfactory installations in constant use. Many mechanics will argue otherwise, thinking

they cannot work unless there is a drop lamp directly over the tool, but this is largely a question of psychology. After a new system has replaced the old, everyone is usually enthusiastic in his praises, after becoming accustomed to the change.

The system to use for lighting machine tools depends on the type of building, as pointed out above.

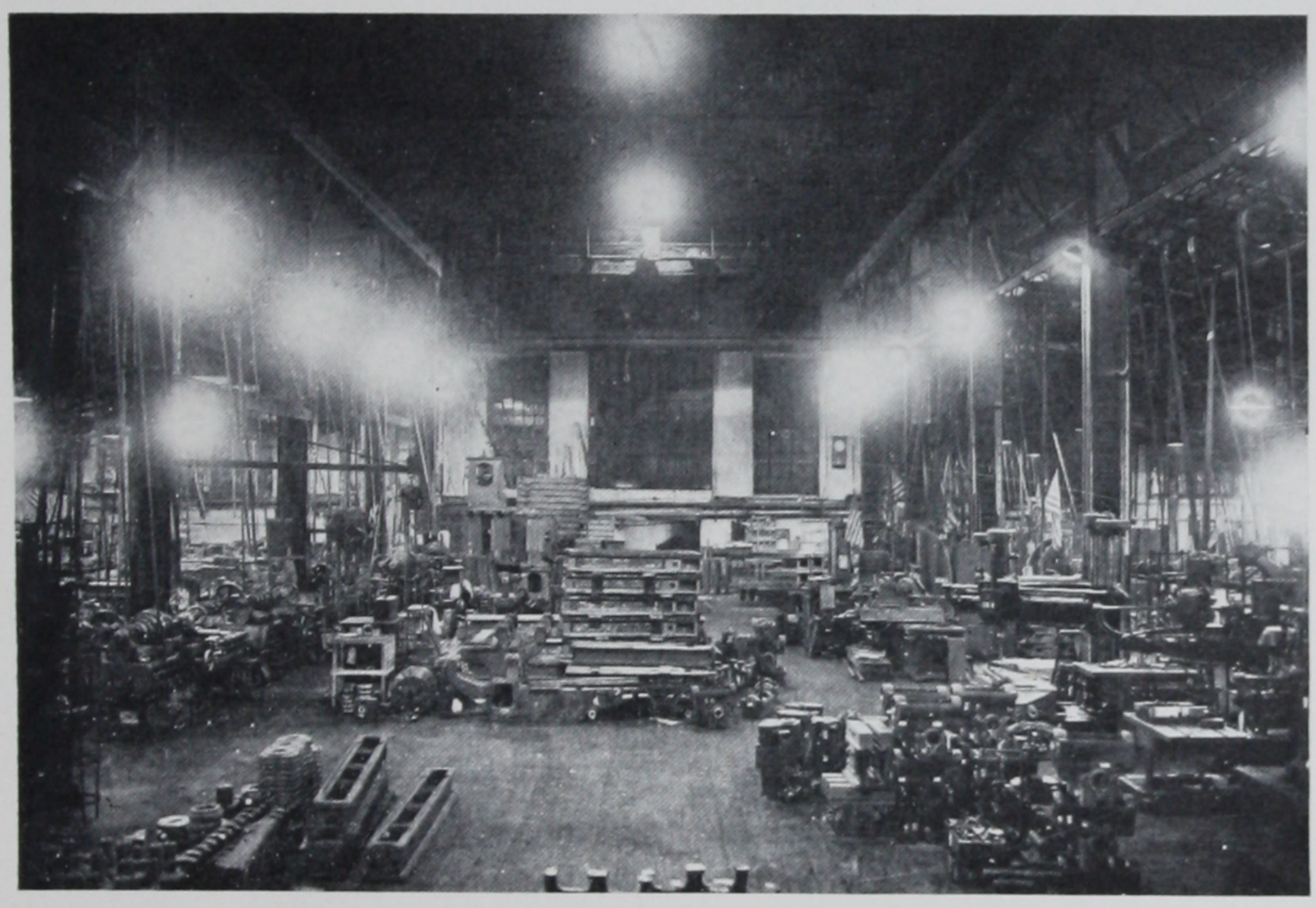

Fig. 10
An Erecting Bay of a Plant Manufacturing Machine Tools as it Appears by Night. Fifty feet high, above the crane travel, is a row of 1000-watt MAZDA C lamps in deep bowl steel reflectors. On the columns, below the crane travel, are placed 300-watt MAZDA C lamps in angle type reflectors. In the side bays, which have lower ceilings, 150- and 200-watt MAZDA C lamps are used in dome type reflectors. This serves as an excellent illustration of the application of the various types of industrial equipment

Strictly general illumination, that is, a symmetrical arrangement of outlets with reference to the bays is quite satisfactory in the high structure, as indicated in Figs. 10 and 11.

There are many degrees of precision requiring different amounts of light and the MAZDA lamp with its wide range of sizes enables these conditions to be met easily. The following table indicates good practice for general lighting of machine tool work:

Rough work, 4 to 6 foot-candles; 0.6 to 0.75 watts per sq. ft.
Average work, 6 to 8 foot-candles; 1.0 to 1.25 watts per sq. ft.
Fine work, 8 to 12 foot-candles; 1.5 to 2.0 watts per sq. ft.

The RLM standard dome reflector with a clear MAZDA C lamp, when the hanging height is over twenty feet, is probably the most universally applicable unit for these conditions. The size of lamp will depend on the spacing and intensity desired. The spacing in turn depends on the hanging height and size of bay. See Bulletin Index 13, "Calculation of the Lighting Installation," for data on determining the correct size of lamp to use.

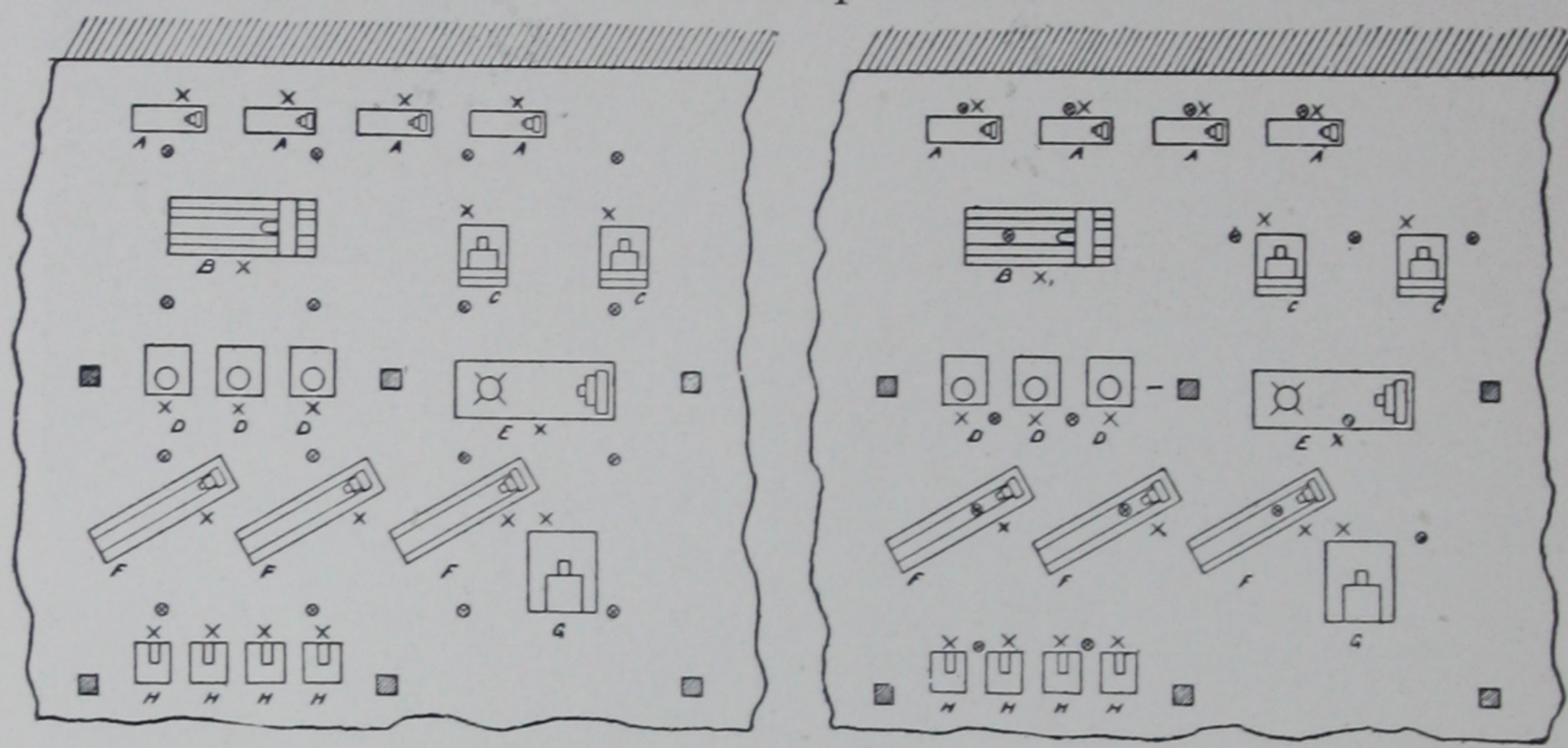

Diagram A

Typical Section of a Machine Shop. At the left is shown the arrangement of outlets for symmetrical general illumination; at the right is shown arrangement of outlets for localized general lighting. A—Lathe (engine). B—Large Planer. C—Shaper. D—Drill Press. E—Lathe (turret). F—Automatic Screw Machine. G—Universal Miller. H—Emery Wheel and Buffer. O—Lighting Outlet. X—Position of Operator

A safe general rule for a satisfactory installation in a machine shop of this nature is that the spacing should be about equal to the distance above the floor, thus in a room where units would be mounted twenty feet, one per twenty-foot bay would be satisfactory. If forty feet high, one unit every two bays, while with the ten-foot mounting height, four units per bay would be desirable.

Where the ceiling is low, in order that the predominant light may come from the proper direction, it is most generally advisable to use localized general lighting which is an intermediate practice between general and local lighting with common sense used in the placement of outlets. In diagram A is shown the difference in arrangement between a general and a localized general lighting layout. In the case of the symmetrical arrangement, an analysis shows that many of the units are quite ineffective. For example, two are located directly behind the shapers in which position they would be of little use. The lighting of the lathes along the wall

would be from the wrong direction; the headstock would cast a shadow on the work. A similar anaylsis might be carried out for the entire hypothetical arrangement. In the other half of the diagram lighting units are arranged so that the correct direction of light results, the position of each machine being taken into consideration.

One might justly bring up the criticism that this is nothing but an extravagant system of local lighting providing a rather large lamp for each machine. On the other hand, one would be willing to grant that with our present standards, the use of four 100- or 150-watt lamps in a twenty-foot bay was not extravagant for general lighting. If the number of units in the four bays pictured is tallied, the general lighting system would show sixteen and the localized general seventeen. An analysis similar to this of entire shops has been made time and time again, and the power required for a localized general system checks up very closely with the power required for a general lighting system.

With such arrangement, each machine receives the kind of lighting it requires. All the advantages of general lighting are obtained and the disadvantages of local lighting eliminated. See Figs. 1 to 5 for examples.

Space will not permit a more detailed discussion of this question which is of great importance, and it is hoped that the example given will indicate the method of attacking a lighting problem of this nature. One should not attempt to place the outlets for a machine shop with a relatively low ceiling without taking into consideration the location of the individual machines.

The size of lamp required for this scheme depends as before on the fineness of the work. For rough work, 75-watt bowl frosted Mazda C lamps in RLM Standard Dome reflectors arranged approximately as shown will prove satisfactory, for average work 100-watt bowl enameled Mazda C lamps in RLM Standard Dome reflectors and for fine work 150-watt units of the same type. Where reflector cap diffusers or similar equipments are used to obtain additional diffusion, it is usually desirable to employ the next larger size of lamp than specified.

The following general rules indicate the desirable direction of light for the different types of machines:

Lathes—From above to the right of the chuck, very slightly forward.

Millers and Shapers—From above, in front, and preferably both sides.

Planers—Large machines above center of bed when at end of cutting stroke;

Small machines—See shapers.

On planers where it is advisable to supply only moderate general illumination a small lamp with reflector may often be mounted near the tool.

Fig. 11
Night View of the Assembly Floor of a Shop Devoted to Heavy Work. 300-watt MAZDA C lamps in dome reflectors are hung above the crane travel twenty feet above the floor. These are on centers 25 x 28 feet. A uniform distribution of light is obtained and the intensity is adequate for safety and efficient handling of the large parts

Drill Presses—From above, in front, unless overhanging parts prevent, then slightly from the side.

Buffers, Grinding Wheels, etc.—Above the wheel, slightly forward.

Saws—In line with the saw, slightly forward.

Sheet Metal Work

Many of the processes in this type of plant are similar to those treated under Machine Tool Work.

Punching, pressing and stamping, contrary to the general impression, can be satisfactorily illuminated by the overhead system

with the predominating light from the front and from the left or right of the operator. It is true that where very large pieces are pressed, overhanging parts may be such as to make it quite essential to install drop lamps in the mechanism of the punch or press. On the other hand, the practice of having a bare unshielded lamp lying on the bed of the press continuously in the operator's field of view should be eliminated.

Fig. 12
Night View of a Plant Devoted to the Assembly of Textile Machinery. 300- and 500-watt Mazda C lamps in RLM Standard dome reflectors are eighteen feet high on 20-foot centers. A uniform intensity of ten-foot candles is secured. With an arrangement such as this, failure of one unit does not render the entire section useless

Under these conditions eye strain is severe, fatigue is increased, and the glare effect with attendant after-image is very likely to be the direct cause of a crushed hand. One certainly can work with a greater degree of safety in a room lighted as pictured in Fig. 6, where the white side walls eliminate shadows, than under the conditions too frequently noted in the punch room.

Cutting, shearing, edge setting, rolling, polishing, burnishing and similar processes can be illuminated satisfactorily by a system

of general lighting providing an intensity of from four to eight foot-candles, depending on the fineness of the work and the degree of accuracy required. An example of the type of machinery encountered in the sheet metal shop well illuminated is to be noted in Fig. 9.

Assembling, Painting, etc.

General illumination is entirely satisfactory for these operations as carried on in the metal working plant. This work usually takes place in the high center bay and the rules laid down for machine tool work in this area apply. The RLM Standard Dome reflector with clear MAZDA C lamps symmetrically spaced above the crane travel as pictured in Fig. 12 or a combination of this unit and angle steel reflectors with bowl enameled lamps below the crane travel are the two most universally applicable methods of applying light here. The angle equipment has the advantage of directing the light from the side and producing excellent illumination on vertical surfaces. It is rarely adequate alone and should be supplemented by overhead units to prevent dense conflicting cross shadows. Fig. 10 indicates the results which are secured with the proper balance of light from different directions.

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